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Impact of treated papermill effluent on yield and quality of Bhendi

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Abstract
An attempt has been made to use the treated paperboard mill effluent and well water with STCR recommended NPK, MLSS (Mixed Liquor Suspended Solids) and pressmud compost as nutrient source for cultivating Bhendi crop to assess their impact on yield and fruit quality. Application of MLSS, Pressmud compost had increased the available nutrients (N, P, K) and organic carbon content in the soil. The treatment combination of 50% STCR recommended NPK + 50% MLSS (Mixed Liquor Suspended Solids) + effluent irrigation performed better compared to other treatments. The experimental results revealed that yield of Bhendi under treated effluent irrigation was higher than well water irrigation. The yield increase was recorded as 31.20 percent over the control (100% STCR NPK + well water). The quality parameters *viz.*, crude fibre and total protein were higher under effluent irrigation.

Keywords: Treated papermill effluent, Bhendi, MLSS, STCR NPK, quality parameters

Introduction
Declining freshwater sources for the expanding population is a major concern in the world. To deal with the situations of fresh water shortages it is necessary to focus on the recycling and reuse of the wastewaters generated from various industries. The treated industrial wastewaters can be used for secondary purposes such as agricultural needs for irrigating the crops. (Kansal, 1994) [1] The organic carbon content and available NPK in the soil were found to be increased in the waste water irrigated soils (Singh *et al.*, 2013) [2] and improve the soil fertility. The pulp and paper industry being one of the largest consumers of fresh water releases a huge quantity of effluent which when used to irrigate crops can be an alternative source of plant nutrients. The paper mill effluent irrigation has improved the soil nutrient status (Kumar *et al.*, 2010) [3] and thereby improve the nutrient availability to the crops. Also effluents from some industries have the potential to improve the crop productivity (Sheela and Peethambaram, 2007) [4] without any deterioration of crop quality. (Palaniswami and Ramulu, 1994) [5] Such effective management would bring economic benefits and also prevent environment degradation.
The vegetable consumption per capita per day in India is 135 g which is much lower than the requirement of 285 g per day. It shows the necessity to raise the vegetable production by increasing the area for cultivation and also increasing productivity of the crops. *Abelmoschus esculentus* (L.) is an economically valuable vegetable crop grown widely in tropical and subtropical countries of the world including India. (Kumar and Chopra, 2013) [6].
To combat the struggles of water scarcity and increasing the vegetable production in an effective way, the present investigation was carried out to study the impacts of treated paper mill effluent on Bhendi crop productivity.

Materials and Methods
The experiment was carried out at Seshasayee Papers and Boards Pvt. Ltd., Pallipalayam, Namakkal district of Tamil Nadu during 2019-2020. Bhendi hybrid Co 4 was used in this study and the experiment was laid out in split plot design. The main plot factors was the irrigation source *viz.*, well water (M_1) and treated effluent (M_2) and the sub plot factors are: 100% STCR recommended NPK (S_1), 50% STCR recommended NPK + 50% pressmud compost (S_2), 50% STCR recommended NPK + 50% MLSS (S_3) and 50% pressmud compost + 50% MLSS (S_4). The STCR based NPK recommendation for the Bhendi hybrid was obtained from the Department of Soil Science & Agricultural Chemistry, TNAU, Coimbatore.

Based on the nutrient status of the soil the STCR (Soil Test Crop Response) recommended NPK was 100:60:98 kg ha^{-1}. The growth attributes, plant height was measured from the ground level to the tip of the main stem at interval of 30, 60 and 90 DAS (Days after Sowing). The yield attributes *viz.*, fruit weight, fruit length and girth were recorded. The crude fibre content and total protein was estimated adopting the procedures given by (Chopra and Kanwar, 1976) (Lowry *et al*., 1951) [7, 8].

Statistical analysis

The statistical tool SPSS (Statistical Package for Social Sciences) was used to compute the ANOVA and determine any significant difference ($P< 0.05$) among the factors. The treatment differences that are not significant were noted as Non-Significant (NS).

Results and Discussion

The soil from the experimental field was characterized and found to have 180, 14.1 and 261 kg ha^{-1} of available N, P and K. The pH, EC and organic carbon were 7.79, 0.26 dSm^{-1} and 0.56% respectively. Also, the pressmud compost and MLSS (Mixed Liquor Suspended Solids) were characterized. The pH, EC, organic carbon was 6.89, 1.93 dSm^{-1}, 38.10% and 7.63, 1.62 dSm^{-1}, 24.10% for pressmud compost and MLSS respectively. The total NPK were 1.53, 0.45, 1.01% and 1.43, 0.93, 0.89% for pressmud compost and MLSS respectively.

Plant biometric observation

The plant height of bhendi measured on different stages during the growth period influenced by the different treatments is given in Table. 1. At the harvest stage highest was recorded (44.4 cm) in 50% STCR NPK +50% MLSS+ Effluent irrigation (M_2S_3) and lowest height (32.2 cm) was in 5% STCR NPK + 50% Pressmud compost +Well water (M_1S_2) followed by (32.33 cm) 50% STCR NPK +50% MLSS+ Well water (M_1S_3). The effluent irrigated treatments performed better in all the growth stages compared to well water. The appreciable amount of plant nutrients present in the treated effluent is responsible for such results. Reports of Udayasoorian *et al.*, (2003) [9] also confirm that effluent irrigated Bhendi record higher plant height than well water irrigation.

Table 1: Effect of treated papermill effluent irrigation on plant height (cm) of Bhendi

Treatments	Plant height (cm)								
	30 DAS			60 DAS			At harvest		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
S_1	11.67	14.07	12.87	20.37	27.17	23.77	35.48	41.47	38.48
S_2	12.20	14.00	13.10	24.33	20.47	22.40	32.20	35.63	33.92
S_3	12.60	13.13	12.87	20.77	25.27	23.02	32.33	44.40	38.37
S_4	11.80	13.27	12.54	23.00	24.00	23.50	37.27	42.27	39.77
Mean	12.07	13.62		22.12	24.23		34.32	40.94	

	SEd	CD (0.05)	SEd	CD (0.05)	SEd	CD (0.05)
M	2.656	5.787	0.763	1.662	1.564	3.407
S	1.533	NS	0.933	2.032	2.331	5.079
MS	1.084	NS	0.440	0.958	1.099	2.394

M_1 – well water; M_2 – treated effluent

S_1 - 100% STCR NPK, S_2 – 50% STCR NPK + 50% Pressmud compost, S_3 – 50% STCR NPK +50% MLSS, S_4– 50% Pressmud compost +50% MLSS.

Yield of Bhendi

The treatments received effluent irrigation recorded higher yield than the well water irrigated treatments. The maximum yield of Bhendi was recorded in M_2S_3 (14.1 t ha^{-1}) which received 50% STCR NPK +50% MLSS + effluent. The lowest yield was recorded in M_1S_1 – 100% STCR NPK +Well water (9.7 t ha^{-1}) followed by M_2S_1– 100% 100% STCR NPK + effluent (9.9 t ha^{-1}). The nutrients present in the treated effluent and the organic load present in the pressmud compost and MLSS have improved the yield of Bhendi crop. Similar results were obtained for different crops like cowpea, (Prasanthrajan *et al*., 2004) [10] chillies and brinjal (Udayasoorian and Ponmani, 2014 and 2009) [11, 12] when treated effluent combined with organic manures.

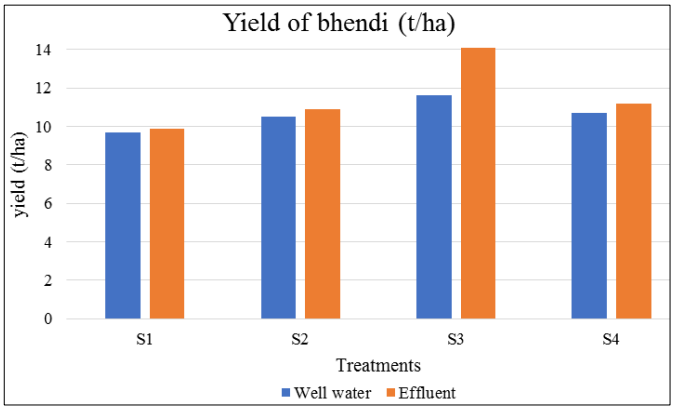
Table 2: Effect of treated papermill effluent irrigation and solid waste on bhendi fruit yield (t/ha)

Treatments	Total yield (t/ha)		
	M_1	M_2	Mean
S_1	9.7	9.9	9.8
S_2	10.5	10.9	10.7
S_3	11.6	14.1	12.85
S_4	10.7	11.2	10.95
Mean	10.63	11.53	

	SEd	CD (0.05)
M	0.435	0.947
S	0.468	1.020
MS	0.221	0.481

M_1 – well water; M_2 – treated effluent

S_1 - 100% STCR NPK, S_2 – 50% STCR NPK + 50% Pressmud compost, S_3 – 50% STCR NPK +50% MLSS, S_4– 50% Pressmud compost +50% MLSS



S_1 - 100% STCR NPK, S_2 – 50% STCR NPK + 50% Pressmud compost, S_3 – 50% STCR NPK +50% MLSS, S_4– 50% Pressmud compost +50% MLSS

Fig 1: Effect of treated papermill effluent and solid waste on bhendi fruit yield (t/ha)

Quality parameters

The quality parameters such as crude fibre and total protein were higher in the effluent irrigated treatments compared to well water irrigated treatments which is similar to the results of Kumar and Chopra (2013) [6]. The combination of treated effluent along with organic manures might have provided enough nutrients rich environment and thus improving soil fertility and crop quality of Bhendi. Crops like radish, onion (Prathiba, 2005) [13], ground nut, (Udayasoorian *et al*., 2004) [14] chillies and brinjal (Udayasoorian and Ponmani, 2009) [12] have also shown similar results when cultivated using treated effluent and organic amendments. The results of fruit weight was higher in effluent irrigated treatments. Similarly in *Allium cepa*, application of organic manure combined with mineral

fertilizers increased bulb qualities like bulb size, total number of bulbs and fresh weight of bulbs (Srivastava *et al*.,2012) [15].

Table 3: Effect of treated papermill effluent irrigation and solid waste on Bhendi fruit quality

Treatments	Crude fibre (%)			Total protein (%)		
	M_1	M_2	Mean	M_1	M_2	Mean
S_1	12.25	12.04	12.1	1.27	1.38	1.3
S_2	12.9	13.11	13.0	1.5	1.62	1.6
S_3	13.13	13.76	13.4	1.74	1.76	1.8
S_4	13.01	13.11	13.1	1.61	1.8	1.7
Mean	12.8	13.0		1.5	1.6	

	SEd	CD (0.05)	SEd	CD (0.05)
M	0.404	NS	0.087	NS
S	0.448	0.977	0.055	0.119
MS	0.211	NS	0.026	0.056

M_1 – well water; M_2 – treated effluent

S_1 - 100% STCR NPK, S_2 – 50% STCR NPK + 50% Pressmud compost, S_3 – 50% STCR NPK +50% MLSS, S_4– 50% Pressmud compost +50% MLSS.

Table 4: Effect of treated papermill effluent irrigation and solid waste on fruit length and girth (cm) and weight (g) of Bhendi

Treatments	Length (cm)			Girth (cm)			Weight (g)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
S_1	11.5	11.1	11.3	5.5	5.5	5.5	16.2	16	16.1
S_2	11.3	9.8	10.6	5.6	5.2	5.4	14.4	14.2	14.3
S_3	11.5	11.5	11.5	5.8	5.6	5.7	13.6	15.9	14.75
S_4	10.5	11.5	11.0	5.5	5.5	5.5	15	16.7	15.85
Mean	11.2	11.0		5.6	5.5		14.8	15.7	

	SEd	CD (0.05)	SEd	CD (0.05)	SEd	CD (0.05)
M	0.524	NS	0.375	1.616	1.039	NS
S	0.792	1.725	0.511	1.113	1.126	2.454
MS	0.373	0.813	0.222	0.484	0.531	1.157

M_1 – well water; M_2 – treated effluent

S_1 - 100% STCR NPK, S_2 – 50% STCR NPK + 50% Pressmud compost, S_3 – 50% STCR NPK +50% MLSS, S_4– 50% Pressmud compost +50% MLSS.

Conclusion

Yield and quality of Bhendi under effluent irrigation and solid waste application was evaluated. Solid waste incorporation along with effluent irrigation increased the yield by 31.20%. This suggests that the cultivation of Bhendi with effluent irrigation is a viable option to increase the productivity.

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